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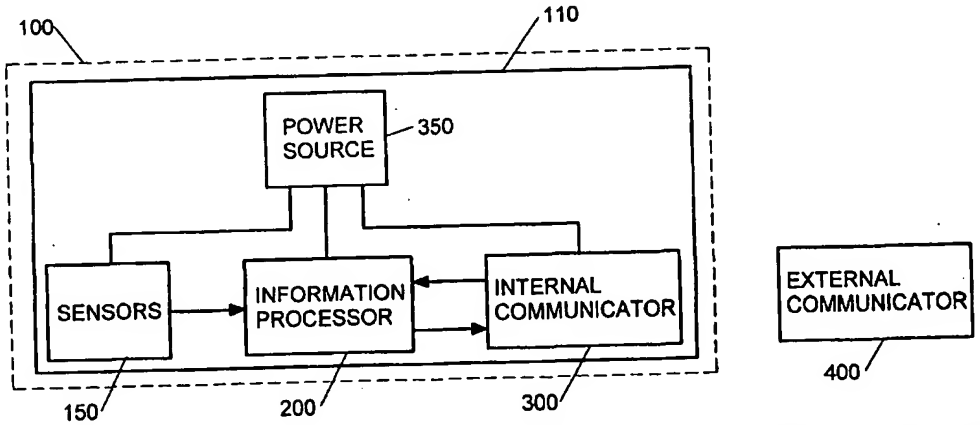
(54) Title: METHODS AND APPARATUS FOR OBTAINING DATA FOR PROCESS OPERATION, OPTIMIZATION, MONITORING, AND CONTROL



(57) Abstract: Data are collected for deriving response models and information required for developing and maintaining processes and process tools. Methods and apparatus for collecting the data include a sensor apparatus (100) capable of collecting data with less perturbation and fewer disruptions than is usually possible using standard methods. The sensor apparatus is capable of being loaded into a process tool. From within the process tool, one embodiment of the sensor apparatus is capable of measuring data, processing data, storing data, and transmitting data. The sensor apparatus has capabilities for near real time data collection and communication.

WO 02/017030 A3

AMENDED CLAIMS

[received by the International Bureau on 07 January 2003 (07.01.03);
original claims 1-3, 5, 11, 13, 14, 16, 17, 19, 21, 23, 24, 27, 32 and 33 amended;
new claims 36-38 added; remaining claims unchanged (8 pages)]

1. A method of deriving operating characteristics for a process tool used for processing workpieces, the method being performed using a sensor apparatus that includes an information processor and embedded executable commands for controlling the apparatus, the method comprising the steps of:

a) loading the sensor apparatus into the process tool;

b) measuring the operating characteristics with the sensor apparatus;

c) converting the measured operating characteristics into digital data using the sensor apparatus;

d) performing at least one step of:

i. storing the digital data in the sensor apparatus, and

ii. storing the digital data in the sensor apparatus and transmitting the digital data to a receiver.

2. The method of claim 1 further comprising the steps of:

transmitting data wirelessly to the sensor apparatus; and

permitting the sensor apparatus to use or store the information wirelessly transmitted to the sensor apparatus.

3. A method of deriving operating characteristics for a process tool used for processing workpieces, the method comprising the steps of:

a) loading a sensor apparatus including electronic devices into the process tool;

b) measuring the operating characteristics with the sensor apparatus;

c) converting the measured operating characteristics into digital data using the sensor apparatus;

d) performing at least one step of:

i. storing the digital data in the sensor apparatus,

ii. transmitting the digital data to a receiver, and

iii. storing the digital data in the sensor apparatus and transmitting the digital data to a receiver, and

e) storing calibration data in the sensor apparatus for use in processing data from the sensors.

4. The method of claim 1 further comprising the step of using the sensor apparatus to mathematically manipulate the measured operating characteristics.

5. A method of deriving operating characteristics for a process tool used for processing workpieces, the method comprising the steps of:

a) loading a sensor apparatus including electronic devices into the process tool;

b) measuring the operating characteristics with the sensor apparatus;

c) converting the measured operating characteristics into digital data using the sensor apparatus;

d) performing at least one step of:

i. storing the digital data in the sensor apparatus,

ii. transmitting the digital data to a receiver, and

iii. storing the digital data in the sensor apparatus and transmitting the digital data to a receiver, and

e) providing sufficient isolation of the sensor apparatus electronic devices to allow the electronic devices to operate in the presence of at least one of electric field, magnetic field, electromagnetic radiation, RF radiation, microwave radiation, temperatures greater than about 100 C, corrosive chemicals, and conditions detrimental to the functioning of the electronic components.

6. The method of claim 1 wherein the sensor apparatus comprises a power source and wherein the method of claim 1 further comprises the steps of:

switching the sensor apparatus electronic devices to reduced operation to conserve power while waiting; and

switching the sensor apparatus electronic devices to normal mode after at least one of

a) a predetermined time,

b) a predetermined amount of time, and

c) receiving a command.

7. The method of claim 1 wherein the sensor apparatus comprises a power source; and further comprising the step of wirelessly recharging the power source.

8. The method of claim 1 wherein step a) comprises using a robot to load the sensor apparatus into the process tool.

9. The method of claim 8 further comprising the step of unloading the sensor apparatus from the process tool using the robot.

10. The method of claim 1 wherein the sensor apparatus is approximately the same size as the workpiece so that the sensor apparatus can be loaded into the process tool using a robot used for loading the workpiece.

11. An apparatus for acquiring data for process tools used for processing workpieces, the apparatus comprising:

a substrate;

at least one sensor supported by the substrate, the sensor being capable of providing information;

an information processor supported by the substrate, the information processor having embedded software for controlling the apparatus, the information processor being connected with the sensor so as to receive information from the sensor;

an internal communicator supported by the substrate, the internal communicator being connected with the information processor so that the information processor can provide information to the internal communicator, the internal communicator being capable of transmitting information received from the information processor;

a power source supported by the substrate, the power source being connected so as to provide power to at least one of:

i. the information processor,
ii. the internal communicator, and
iii. the sensor;

the information processor being capable of at least one of

a) storing digital information, and
b) storing digital information and transmitting digital information to the internal communicator.

12. The apparatus of claim 11 wherein the at least one sensor comprises a plurality of substantially the same type of sensors or a plurality of sensors that include different types of sensors.

13. The apparatus of claim 11 wherein the internal communicator is capable of wirelessly transmitting information to a receiver.

14. The apparatus of claim 13 wherein the connection between the information processor and the internal communicator allows bi-directional information transfer and wherein the internal communicator is capable of wirelessly receiving data.

15. The apparatus of claim 11 wherein the information processor comprises a microprocessor and a memory, the microprocessor and the memory are connected to allow information transfer.

16. The apparatus of claim 15 wherein the memory comprises random access nonvolatile memory.

17. The apparatus of claim 11 wherein the power source is capable of being recharged wirelessly and the power source comprises a battery or a capacitor.

18. The apparatus of claim 11 wherein the power source comprises a battery and an output voltage regulator, the regulator being connected to the output of the battery so as to provide a substantially constant voltage output for the power source.

19. An apparatus for acquiring data for process tools used for processing workpieces, the apparatus comprising:

a substrate;

at least one sensor supported by the substrate, the sensor being capable of providing information;

an information processor supported by the substrate, the information processor being connected with the sensor so as to receive information from the sensor;

an internal communicator supported by the substrate, the internal communicator being connected with the information processor so that the information processor can provide

information to the internal communicator, the internal communicator being capable of transmitting information received from the information processor;

a power source supported by the substrate, the power source being connected so as to provide power to at least one of:

i. the information processor,

ii. the internal communicator, and

iii. the sensor;

the information processor being capable of at least one of

storing digital information, and

storing digital information and transmitting digital information to the internal communicator; and wherein the power source is capable of being recharged wirelessly via magnetic induction.

20. The apparatus of claim 11 wherein the substrate has a cavity for partially or substantially completely containing at least one of:

i. the information processor,

ii. the power source, and

iii. the internal communicator.

21. The apparatus of claim 11 wherein the internal communicator is capable of transmitting information to the exterior of the process tool using sound.

22. The apparatus of claim 14 wherein the internal communicator is capable of transmitting and receiving information using energy from the electromagnetic spectrum.

23. The apparatus of claim 14 wherein the energy is infrared electromagnetic energy.

24. An apparatus for acquiring data for process tools used for processing workpieces, the apparatus comprising:

a substrate;

at least one sensor supported by the substrate, the sensor being capable of providing information;

an information processor supported by the substrate, the information processor being connected with the sensor so as to receive information from the sensor;

an internal communicator supported by the substrate, the internal communicator being connected with the information processor so that the information processor can provide information to the internal communicator, the internal communicator being capable of transmitting information received from the information processor;

a power source supported by the substrate, the power source being connected so as to provide power to at least one of:

i. the information processor,
ii. the internal communicator, and
iii. the sensor;

the information processor being capable of at least one of
storing digital information, and
storing digital information and transmitting digital information to the internal communicator; and

a shield partially or substantially completely surrounding at least one of the information processor, the power source, and the internal communicator; the shield being capable of at least one of:

i. allowing the electronic devices to operate under conditions detrimental to the functioning of the electronic devices, and
ii. substantially preventing exposure of the process tool to contaminants from sensor apparatus.

25. The apparatus of claim 20 wherein the substrate is capable of substantially maintaining a vacuum within the cavity.

26. The apparatus of claim 20 further comprising a shield, the shield being capable of substantially isolating at least one of

i. the information processor,
ii. the power source, and
iii. the internal communicator

so that the sensor apparatus can operate when exposed to the process conditions.

27. A method of operating a sensor apparatus comprising embedded software for the steps of:

a) initializing the sensor apparatus;

b) causing the sensor apparatus to do at least one step of

i. collecting and processing data,

ii. sending data to a receiver,

iii. storing data, and

iv. executing an operational command.

28. The method of claim 27 further comprising between step a) and b) the step of causing the sensor apparatus to enter a sleep mode until at least one of

i. a predetermined time,

ii. a predetermined amount of time, and

iii. receiving a command.

29. The method of claim 28 wherein the method loops back to the step of entering the sleep mode after completing step b).

30. The method of claim 28 further comprising the step of storing calibration data in the sensor apparatus.

31. The method of claim 27 further comprising the step of monitoring the level of power of a power source for the sensor apparatus.

32. A method of operating a manufacturing facility for processing workpieces, the method comprising the steps of:

a) providing at least one process tool capable of processing workpieces, wherein the process tool is part of the manufacturing facility;

b) providing a sensor apparatus having embedded software for controlling the sensor apparatus, wherein the sensor apparatus is capable of collecting and wirelessly transmitting or storing data from within the process tool;

c) measuring process data for the process tool using the sensor apparatus;

d) performing at least one step of

i. monitoring the performance of the process tool using data from the sensor apparatus, and

ii. maintaining the performance of the process tool in response to the data from the sensor apparatus.

33. The method of claim 32 wherein the workpieces comprise substrates for flatpanel displays.

34. The apparatus of claim 11 wherein the substrate has dimensions and properties approximately equal to those of the workpiece.

35. The apparatus of claim 11 having an area footprint in the range of greater than 0 percent and not greater than about 20 percent of the area of the workpiece.

36. The apparatus of claim 11 wherein the power source is capable of being recharged wirelessly via magnetic induction and the power source comprises a battery or a capacitor.

37. The method of claim of 1 wherein the information processor comprises a microprocessor.

38. The apparatus of claim 11 wherein the information processor comprises a microprocessor.